STATUS OF A NEW SWITCHYARD DESIGN FOR LANSCE*

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Abstract

Funding was recently received to study modifications of a section of the LANSCE beam switchyard. At present, the switchyard is used to deliver a proton beam to experimental Area A and an H^--ion beam down Line D. The total H^- repetition rate is 120 Hz. 100 Hz is transported to the Weapons Neutron Research (WNR) area. The remaining 20 Hz is injected into the Proton Storage Ring (PSR). In order to provide H^- beam to other experimental areas without interfering with the PSR operations, a new design of the switchyard is in progress. We are presently investigating a solution that would use pulsed kicker magnets to deflect a fraction of the WNR H^- beam down a separate existing beam-line at the demand of the experimenters.

1 INTRODUCTION

The Los Alamos Neutron Scattering Center (LANSCE) accelerator complex consists of an 800-MeV linear accelerator, a proton storage ring (PSR), and a number of experimental areas. Two beams are presently accelerated simultaneously on alternating cycles of the rf. The linear accelerator consists of two 0.75-MeV Cockroft-Walton injectors, one supplying protons and the other supplying H^- ions. A separate low-energy beam transport line exists for each beam species. A 0.75-MeV to 100-MeV drift-tube linac operating at 201.25 MHz, a 100-MeV transition region, and a 100 to 800-MeV side-coupled linac operating at 805 MHz is used to accelerate the two beams. Typically, peak beam currents as high as 18 mA are transmitted for variable duty factors to give a maximum average beam current of 1 mA for the H^+ beam and up to 100 μA for H^-.

A beam switchyard is used to direct beams from the linac to various experimental areas and for injection into the PSR. The 800-MeV proton beam is presently sent to an experimental area (Area A) via a separate beam-line where it presently interacts with a series of different targets for the Accelerator Production of Tritium program and for isotope production. Up to 3 μA of the 800-MeV H^- beam is sent to the Weapons Neutron Research Facility (WNR) where it strikes a target producing an intense white-neutron source. Since variable proton pulse widths are available, time-of-flight experiments for neutron energies ranging from a few MeV to 800 MeV are possible.

The PSR functions as a high-current accumulator or pulse compressor to provide intense pulses of 800-MeV protons to the Manual Lujan Jr. Neutron Scattering Center (Lujan) spallation neutron-production target. This target was upgraded for higher-average-current operation this year. The PSR operates at a repetition rate of 20 Hz. An entire linac macro-pulse is accumulated each turn around the ring with up to 2800 turns accumulated prior to single-turn extraction.

We recently received internal funding to study technical options that would greatly enhance our existing capabilities. We are presently performing simulation and conceptual design studies to determine the most cost-effective reconfiguration of a section of the beam switchyard. A diagram of the unmodified switchyard is shown in Fig. 1. The desired solution should allow simultaneous, uninterrupted beam delivery to Line D (PSR injection) and delivery of a "tailored" H^- beam-pulse to either Line B or Line C on the demand of the experimenters. The beam-pulse delivered on-demand will be diverted from the 100 Hz beam normally delivered to WNR.

Simultaneous beam delivery to Line B/C and Line D is not possible at present. A few hours are required to accomplish the required changes to allow the H^- beam to be directed from Line D to Line B/C. Delivery of beam to all users of this beam is interrupted during this transition period.

Immediate beneficiaries of this study will include the proton radiography program, neutron resonance spectroscopy studies, Lujan neutron scattering users, and WNR users at LANSCE. Other programs that may also benefit may include an ultra cold neutron facility and the future Dynamic Experimentation Laboratory. Implementation of a proposed solution will be contingent upon receiving additional project funding.

2 TECHNICAL REQUIREMENTS

Beam delivery for the present Line B/C users requires delivery of 800-MeV protons with ~2-3x10^8 protons per 5 ns (201.25 MHz) micro-pulse. The present ion-source and linac are capable of delivering this beam to the switchyard. The number and sequence of micro-pulses delivered, per macro-pulse, is determined by the accelerator master-timer and controls software. Modifications to this software will be required to fully

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implement any proposed solution and satisfy programmatic requirements.

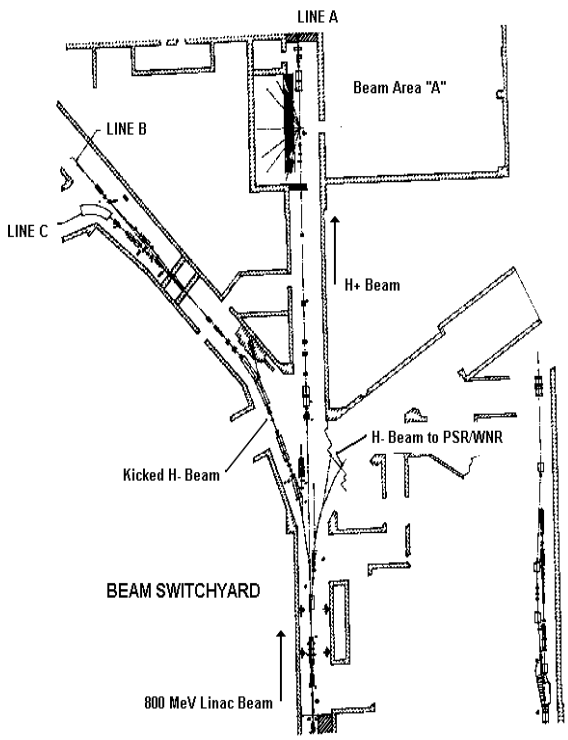

Figure 1 – LANSCE Beam Switchyard

Any proposed kicker solution must be capable of continuously delivering full-beam macro-pulses, for tuning, at a repetition rate of 1-20 Hz to Line B/C. The magnet response time requirement is 8 ms. This is the time between beam macro-pulses (120 Hz). Additionally, the capability to deliver a single macro-pulse on demand must be possible. Preserving the capability to operate in all the other existing facility modes is also a requirement. In particular, operation should not interfere with the 20 Hz H^- beam delivery for injection into the PSR. A desired feature, although not absolutely necessary, is that the solution be achromatic.

3 A TWO-KICKER SOLUTION

A schematic diagram of the unmodified H^- beam-line where the split between Line B/C and Line D occurs is shown in Fig. 2. The diagram is not to scale, but shows the general features of this area of the beam switchyard that we are proposing to modify.

3.1 TRANSPORT Results

We have modeled a two-kicker solution using TRANSPORT [1]. This solution requires the removal of the disabled kickers, the dipole bender, and the beam vacuum box just before the beam-line split (See Fig.2). These components would be replaced with two d.c. dipole magnets and two pulsed dipole kicker magnets. A new vacuum beam box design would also be required to match the new configuration to the existing beam-lines. Figure 3 shows a conceptual layout for this solution. The figure is not drawn to scale and only illustrates the relative positioning of the beam-line components.

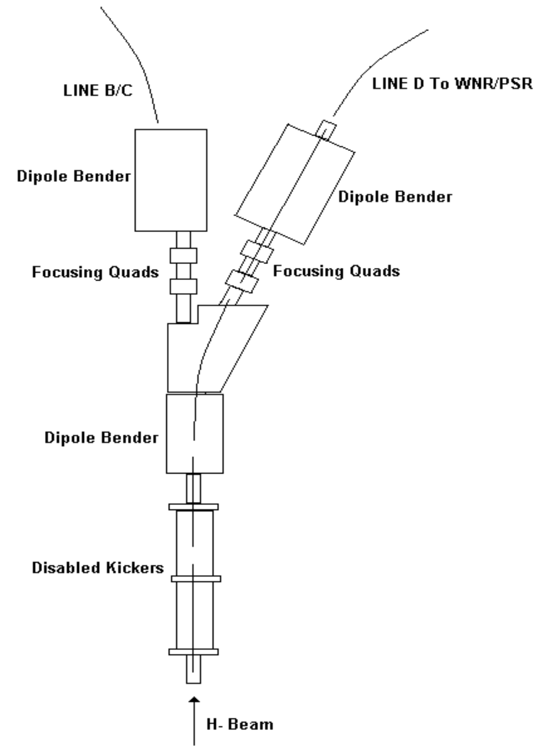

Figure 2 – Schematic of the Line B/C and Line D split in the LANSCE beam switchyard.

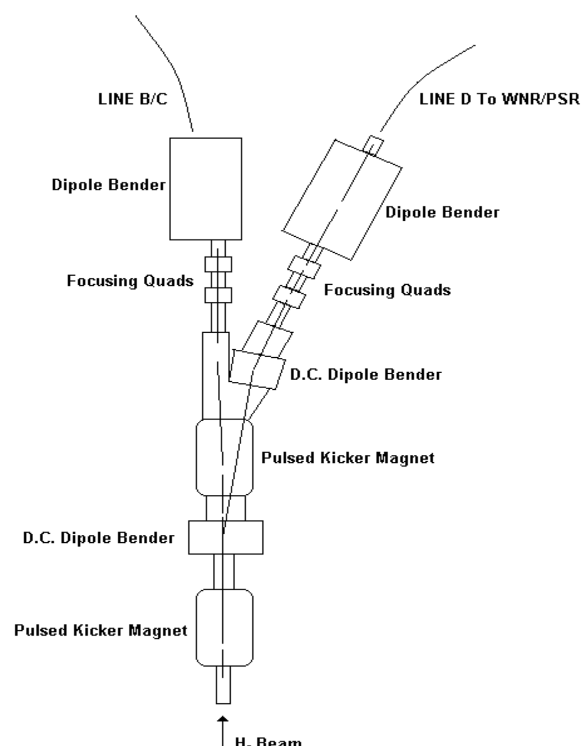

Figure 3 – Schematic of the proposed two-kicker solution

The two smaller d.c. dipole magnets will provide the same total bend angle of the single larger dipole magnet for the normal operation mode where beam is delivered down Line D. When the two kickers are fired, the beam is deflected in each kicker an amount equal to the bend of the first d.c. dipole, thus canceling out its effect. Beam is then delivered down Line B/C when the kickers are on.

The solution shown is also achromatic. This should help to preserve the relatively small linac energy spread. Table 1 gives the bend angle, field, and effective length requirements for the new magnets based on the simulation results.

Table 1 – New magnet parameters for the two-kicker solution.

Magnet	**Effective Length (m)**	**Field (KG)**	**Bend Angle (deg)**
Pulsed Kicker	1.016	1.26	1.5
DC Dipole	0.724	3.53	3.0
Pulsed Kicker	1.016	1.26	1.5
Dipole	0.656	3.53	2.7192

3.2 Kicker Magnet and Pulsed-Power System

The magnet requirements, as determined by the simulations, for this solution will allow use of a pulsed magnet and power-supply similar in design to that of the pulsed ring injection kicker magnet (RIKI) for the PSR at LANSCE [2].

The RIKI magnet is typically operated at 20 Hz. It can, however, also be operated in d.c. mode. This magnet is a laminated H-magnet with 20-turns/coil using hollow water-cooled conductor.

The pulsed-power system will provide a controlled current pulse to each kicker magnet. The RIKI pulsed-power system is capable of producing a current pulse with an amplitude that can be set in a range from 180 to 220 A with a flat-top width of up to 1.4 ms. Repetition rates ranging from 1 to 40 Hz have been tested with pulse regulation better than ± 0.5 %.

This system operates by resonantly discharging a capacitor of known voltage into a kicker magnet of known inductance through the following cycle. Initially, the current in the magnet builds resonantly. After the current has peaked, the circuit goes into "Freewheel" mode producing a settable flat-top of up to 1.4 ms width. Finally, the circuit goes into recovery mode where most of the stored energy in the magnet is recovered by returning it to the pulse capacitors. Implementing the firing of both kickers simultaneously and the potential problems that may be caused by timing errors have not yet been investigated.

3.3 Hardware Controls Requirements

We have estimated the approximate number and types of data channels that will be required for a flexible implementation scheme able to accommodate the final versions of the kicker power supplies. Our estimation is based on our past implementation of the RIKI magnet power-supply controls into the LANSCE control system. The RIKI power supply has control functions that use 9 binary input channels to indicate status and 5 binary command channels to provide on/off controls and reset functions. Two analog read-back channels are required to indicate voltage and current. One analog command channel is used to set the output current level. The modular design of the control system hardware provides the adaptability and flexibility required to implement the actual power supply controls.

One possible controls-hardware configuration is as follows. A VME crate using a Motorola processor module connected to the control system's Ethernet network can provide the foundation for the system and create an Experimental Physics and Industrial Control System (EPICS) input/output controller [3]. The use of the EPICS system allows existing operator interfaces to be used with a minimum of modifications, thereby reducing the cost of the system. The addition of VME Industry Pack carriers and Industry Packs, to provide the necessary signal conditioning, will complete the system. Industry Packs are small cards that perform specific I/O functions and are mounted on carrier boards for the bus system they are housed in. The interface between the Industry Pack and the carrier board is defined in the standard, ANSI/VITA 4-1995. Selection of Industry Packs similar to those already used in the control system can reduce the cost of software development. Local control for the power supply must be provided on each unit. This implementation has the advantage of providing isolation of the power supply control from the rest of the control system along with a modular design to increase maintainability and reduce system downtime.

4 SUMMARY

A solution for modification of the LANSCE switchyard has been described. In future studies, other solutions will be sought and compared to the two-kicker solution presented here.

REFERENCES

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